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FINAL REPORT

DEVELOPMENT OF A MULTI-METAL PRIMER

BY

STANLEY F. KOUTEK

OCTOBER 1969

U. S. ARMY ABERDEEN RESEARCH & DEVELOPMENT CENTER
COATING & CHEMICAL LABORATORY
Aberdeen Proving Ground
Maryland

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COATING AND CHEMICAL LABORATORY
ABERDEEN PROVING GROUND
MARYLAND 21005

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ABSTRACT

Some currently employed specification epoxy primers and experimental formulations were exposed at the Panama test sites for corrosion resistance studies. Inhibiting pigments considered included strontium, zinc and basic zinc chromates up to 90% by weight of the total pigmentation at different pigment volume concentrations. Polyamide and amino-silane curing agents were used. Experimental vinyl and polyurethane primers offered no significant improvement in corrosion resistance when compared to two existing specification primers, particularly on pretreated substrates. It is recommended that MIL-P-52192, Primer Coat, Epoxy be used for ferrous substrates and MIL-P-23377, Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant, for aluminum, magnesium or bi-metallic materials.

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I. INTRODUCTION

A study was initiated for the development of a multi-metal epoxy primer as reported in CCL Report No. 192, 24 February 1966. This work indicated that further information was needed concerning performance of epoxy primers in corrosive and humid atmospheres before a decision could be made as to which type provided the maximum desired results. With this in mind, an exterior exposure study was conducted at the Panama exposure sites. This location was selected because atmospheric and environmental conditions provided, in a reasonable length of time, a means of reliably evaluating the primers.

II. DETAILS OF TEST

A. Preparation of Coatings

All pigmented resin components were prepared by charging the vehicle, pigments and necessary solvents into a pebble mill and grinding for 24 hours. All catalyst components consisted of a blend of the curing agent with the required solvents.

B. Test Panels

Flat polished 4 by 12 inch cold-rolled automotive steel, 2024 aluminum and AZ-31 magnesium were cleaned and pretreated in accordance with methods listed under Surface Preparation, Table I (Appendix A).

C. Application of Coatings

All primers were applied by spray to a dry film thickness of 0.9 to 1.1 mils. Primers which were topcoated were allowed to air dry 2 hours before spraying a 0.9 to 1.1 mil dry film thickness topcoat of Olive Drab Semi-Gloss Enamel conforming to Specification TT-E-529, Class A.

D. Panama Exposure

Scored test panels placed at the Panama Breakwater and Rain Forest sites were evaluated approximately twice a year in accordance with the rating system of Table II (Appendix A).

III. DISCUSSION

A study on the Development of a Multi-Metal Epoxy Primer, Progress Report CCL No. 192, showed an experimental epoxy primer furnished better corrosion resistance to aluminum and magnesium substrates than specification Epoxy Primer MIL-P-52192, but was inferior on steel along the score.

Based on the data obtained from this work, it was decided to conduct further corrosion resistance studies by placing at the Panama Breakwater site some currently employed specification epoxy primers and additional

experimental formulations. The Panama Test Sites are situated on the Atlantic Sector of Panama at Fort Sherman, Panama Canal Zone. The Breakwater site is located at the junction of Limon Bay and the Caribbean Sea on a jetty separating the sea from the bay, with panel racks positioned 30° from the vertical and facing the prevailing trade winds. Thus, a severely corrosive atmosphere is present at all times and metal attack is accelerated in comparison to other environments. The Rain Forest is located approximately 4 miles inland from the Breakwater site in the Tropical Evergreen Forest that is composed of basically 3 tiers of tree growth ranging from 20 to 125 feet high. In this region high humidity conditions prevail.

The epoxy primer formulations are given in Appendix B and include MIL-P-52192, MIL-P-27316 and MIL-P-23377A, Formulas 1, 2 and 3 respectively. The previous developed experimental epoxy primer control is shown in Formula 4 and zinc and strontium chromate epoxy primers are given in Formulas 5 and 6. Primers 5 and 6 are cured with a polyamide, aminosilane coreactant to utilize the wetting and adhesion properties attributed to these reagents.

Breakwater exposure data is given in Appendix C, Tables I through VII. On zinc phosphate pretreated (TT-C-490, Type I) Steel, MIL-P-52192 offered the best score protection although heavy score rusting developed within 12 months. Primers 2, 5 and 6 were definitely inferior. MIL-P-23377A and the experimental epoxy control primer were comparable when topcoated. All primers without the TT-E-529 topcoat developed surface and substrate defects.

On solvent cleaned aluminum primed with MIL-P-23377A and topcoated with TT-E-529, excessive score undercutting developed within 6 months Breakwater exposure. Likewise, MIL-P-52192 failed along the score. Other primers were generally comparable with the experimental epoxy primer control providing the best overall protection. On aluminum chemically pretreated with MIL-C-5541, performance improved significantly. MIL-P-52192 and MIL-P-27316 without topcoats were unsatisfactory along the score; all other primers, with and without topcoats, were comparable having only slight score defects.

On solvent cleaned magnesium, primers 1, 2 and 6 were unsatisfactory after 6 months exposure. The remaining primers developed score and/or surface-substrate defects within 12 months. MIL-P-23377A was the best among the specification primers and the experimental epoxy primer control had the least score attack. MIL-P-52192 and MIL-P-27316 were inferior to MIL-P-23377 and the experimental primers on all pretreated magnesium substrates. Differences between pretreatments were not excessive, however, MIL-M-3171, Type III appeared the most effective.

From the data, it is apparent that none of these epoxy primers would function as a multi-metal primer. MIL-P-52192 would be preferred on steel, MIL-P-23377A and the experimental epoxy control appeared better

on aluminum and magnesium pretreated substrates. The experimental zinc and strontium chromate primers offered no definite improvement, nor did the curing agents.

Previous Panama exposure tests indicated that MIL-P-15930B, Vinyl Zinc Chromate Primer, performed among the better primers on steel substrates. Accordingly, a second exposure study was initiated using MIL-P-15930B as a control and formulating that pigmentation into epoxy primers at the pigment volume concentration (PVC) of MIL-P-15930B, 25.9 percent, and at the experimental epoxy primer control of 35.2 percent. Further, basic zinc chromate content was increased to 90 percent of the pigment in the same vehicle formulations. Both polyamide and amino-silane curing agents were used. Included in the study were MIL-P-52192, the experimental epoxy primer control and MIL-P-23377A, amended, which increased the strontium chromate content to 52-54 percent by weight of the pigment from 15.6 percent. A polyurethane, aliphatic diisocyanate cured two package primer, Formula 19, pigmented as MIL-P-15930B at the Specification PVC, was added to investigate the corrosion resistance properties of this type system. The primers are shown in Formulas 1, 4 and 7 to 19 inclusive.

Exposure studies were conducted at the Panama Breakwater and Rain Forest sites. The primers were tested on zinc phosphate (TT-C-490, Type I) pretreated steel, alkali cleaned and chemically (MIL-C-5541, Type II) pretreated aluminum and alkali cleaned and anodically (MIL-M-45202, Type I) pretreated magnesium. Alkali cleaning insured a more uniform substrate surface than was possible by the solvent cleaning method.

Breakwater Exposure (Tables VIII-XII)

Primers 1, 8, 14 and 19 were slightly better along the score on zinc phosphated steel than the remaining primers after 6 months exposure. Differences were negligible after 15 months with defects confined to the scored areas except for primer 18. After 21 months some surface blistering and rusting occurred on vinyl primer 8 and amino-silane epoxy primers 14, 16 and 18, all containing 90 percent basic zinc chromate. The polyurethane primer 19 likewise exhibited similar attack. Polyamide primers and MIL-P-52192 were without surface or substrate defects. None of the experimental primers offered improved corrosion resistance over MIL-P-52192 and MIL-P-23377A was only slightly inferior along the score. Differences in pigment volume concentration had little effect on performance.

On alkali cleaned aluminum, MIL-P-52192 was unsatisfactory along the score after six months and in 15 months primers 1, 7, 11, 12 and 19 had excessive score defects. Primers 10, 17 and 18 had no defects after 21 months exposure. The experimental epoxy control primer and amended MIL-P-23377A were comparable. Vinyl primers 7 and 8 had poor adhesion to the aluminum substrate in addition to score failures.

MIL-P-52192 developed score blisters within six months when applied to chemically pretreated aluminum. MIL-P-23377A, amended, and primers

11, 13, 17 and 18 were without defects after 21 months. The polyurethane primer was rated below these. All primers had minor score blistering. Pigmentation and pigment-volume concentration differences had little effect. Polyamide cured primers appeared slightly better than the corresponding amino-silane types.

Over alkali cleaned magnesium only the amino-silane cured primers 4, 12 and 16 were considered acceptable after 21 months exposure. MIL-P-23377A, amended, was overall better than MIL-P-52192. All primers on anodically pretreated magnesium, except 14 and 18, were satisfactory after 21 months exposure, developing only light score corrosion.

Rain Forest (Tables XIII-XVII)

MIL-P-52192 and the experimental epoxy control primer were without defects after 21 months on zinc phosphate pretreated steel. The remaining primers had traces of score blisters.

On both alkali cleaned and chemically pretreated aluminum, MIL-P-52192 and the polyurethane primer blistered excessively along the score. All other primers were either without defects or had only slight score blistering.

Surface blisters and some substrate pitting was evident on primers 1, 8, 9, 10, 11, 15, 16 and 19 when exposed 21 months on alkali cleaned magnesium. Primer 17 had score defects. The experimental epoxy control primer and in general lower PVC primers performed the best. On anodically pretreated magnesium, the specification primers were satisfactory.

IV. CONCLUSIONS

The experimental primers offered no significant improvement in corrosion resistance over the existing epoxy specification primers MIL-P-52192 and MIL-P-23377A on pretreated substrates. On untreated light metal substrates, the amino-silane cured epoxy primers performed somewhat better than the other types. However, for optimum corrosion resistance, surfaces to be painted should be given a pretreatment prior to coating and specification epoxy primer MIL-P-23377A was adequate under these conditions. The polyurethane primer as formulated in this report is inferior to the specification epoxy primers.

It is recommended that where resistance properties of epoxy coatings are required, MIL-P-52192 be applied to ferrous substrates and MIL-P-23377A be used on light metal substrates. In the event of multi-metal fabrication, MIL-P-23377A would be preferred.

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APPENDIX A - TABLES

TABLE I

SURFACE PREPARATION

Steel	
TT-C-490, Type I	Zinc Phosphate Chemical Conversion Coating
Aluminum	
Solvent Cleaned	1:1 by volume aliphatic naptha (TT-N-95) - Ethylene Glycol Monoethyl Ether (TT-E-781)
Alkali Cleaned	Hot Trisodium Phosphate followed by Deoxidizing in 50% Nitric Acid
MIL-C-5541	Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys, Type II, Grade C, Class 2
Magnesium	
Solvent Cleaned	1:1 by Volume Aliphatic Naptha (TT-N-95)-Ethylene Glycol Monoethyl Ether (TT-E-781)
Alkali Cleaned MIL-M-3171	"Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion Protection On" Type I Chrcmate Pickle Treatment Type II Dichromate Treatment
MIL-M-45202	"Magnesium Alloys, Anodic Treatment Of" Type I, Class C, Light Green Coating

TABLE II

Rating System

I. Score Condition

Rating	Corrosion and/or Blistering
5	None - 1/32 inch
4	1/32 - 1/16 inch
3	1/16 - 1/8 inch
2	1/8 - 3/16 inch
1	3/16 - 1/4 inch
0	> 1/4 inch

II. Undercutting at Score

Rating	
5	None - intermittent
4	Continuous to 1/16 inch
3	Continuous to 1/16 - 1/8 inch
2	Continuous to 1/8 - 3/16 inch
1	Continuous to 3/16 - 1/4 inch
0	Continuous > 1/4 inch

TABLE II - Continued

III. Surface Condition*

Rating	A. Corrosion Alone
5	None
4	ASTM Photo No. 10, Type 1[1]
3	ASTM Photo No. 9, Type 1
2	ASTM Photo No. 8, Type 1
1	ASTM Photo No. 7, Type 1
0	ASTM Photo No. 6, Type 1 or Worse

Rating	B. Corrosion Accompanied by Blistering
5	None
4	Trace, less than 5 defects on 4x12 inch panel
3	ASTM Photo No. 8, Type 2[1]
2	ASTM Photo No. 7, Type 2
1	ASTM Photo No. 6, Type 2
0	ASTM Photo No. 4, Type 2 or Worse

Rating	C. Blistering Alone
5	None
4	Trace - ASTM Blister Size 2 on 4x12 inch panel - 2 max.[2] ASTM Blister Size 4 on 4 12 inch panel - 4 max. ASTM Blister Size 6 on 4x12 inch panel - 6 max. ASTM Blister Size 8 on 4x12 inch panel - 8 max.
3	ASTM Few - Record Blister Size
2	ASTM Medium - Record Blister Size
1	ASTM Medium-Dense - Record Blister Size
0	ASTM Dense - Record Blister Size

*Select applicable condition.
[1]Reference Standards - Federal Test Method No. 141a, Method 6451.
[2]Reference Standards - Federal Test Method No. 141a, Method 6461.

TABLE II - Continued

IV. Substrate Condition

Rating	Pitting and/or Corrosion Spots
5	None
4	Trace - ASTM Blister Size 2 on 4x12 inch panel - 2 max.[2] ASTM Blister Size 4 on 4x12 inch panel - 4 max. ASTM Blister Size 6 on 4x12 inch panel - 6 max. ASTM Blister Size 8 on 4x12 inch panel - 8 max.
3	ASTM Few - Record Size
2	ASTM Medium - Record Size
1	ASTM Medium-Dense - Record Size
0	ASTM Dense - Record Size

[2]Reference Standards - Federal Test Method No. 141a, Method 6461.

APPENDIX B - FORMULAS

Specification Epoxy Primer Coatings

Ingredient	MIL-P-52192 Formula 1		MIL-P-27316 Formula 2	
	Pounds	Gallons	Pounds	Gallons
Component A, Pigmented Epoxy Resin				
Red iron oxide	71.6	1.67	--	--
Basic Lead silico chromate	190.0	5.57	--	--
Calcium chromate	--	--	240.3	6.60
Rutile titanium dioxide	--	--	242.1	6.92
Fibrous magnesium silicate	51.8	2.18	--	--
Micronized magnesium silicate	51.8	2.29	--	--
Suspension agent	4.0	0.27	--	--
Epoxy resin, 450-550 epoxide eq.	139.2	13.85	--	--
Epoxy resin, 2000-2500 epoxide eq.	72.3	7.57	--	--
Epoxy resin, 2500-4000 epoxide eq.	--	--	204.9	20.66
Urea formaldehyde resin, 60% N.V.	13.4	1.58	--	--
Xylene	158.3	21.92	--	--
Toluene	--	--	148.4	20.56
Methyl isobutyl ketone	29.9	4.48	116.6	17.45
Butyl alcohol	96.3	14.27	--	--
Cellosolve acetate	35.8	4.42	--	--
Cellosolve	--	--	198.5	25.61
Isopropyl alcohol	--	--	14.5	2.20
	914.4	80.07	1165.3	100.00
Component B, Catalyst				
Amine adduct	80.8	9.62	--	--
Polyamide resin	--	--	107.6	12.96
Methyl isobutyl ketone	24.9	3.73	166.1	24.86
Cellosolve	24.8	3.20	200.0	25.75
Xylene	24.9	3.45	179.5	24.86
Toluene	--	--	40.4	5.60
Isopropyl alcohol	--	--	39.3	5.97
	155.4	20.00	732.9	100.00
Pigment volume concentration	32.1%		28.6%	

Specification and Experimental Control Epoxy Primer Coatings

Ingredient	MIL-P-23377A Formula 3 Pounds	MIL-P-23377A Formula 3 Gallons	Experimental Control Formula 4 Pounds	Experimental Control Formula 4 Gallons
Component A, Pigmented Epoxy Resin				
Strontium chromate	54.2	1.61	54.2	1.61
Rutile titanium dioxide	119.0	3.40	--	--
Red iron oxide	--	---	271.1	6.46
Fibrous magnesium silicate	115.3	5.11	211.8	8.92
Diatomaceous silica	59.5	3.57	--	--
Suspension agent	--	---	5.4	0.36
Silicone resin, 60% N.V.	--	---	4.9	0 60
Epoxy resin solution, 75% N.V., 450-550 epoxide eq.	377.6	41.68	---	--
Epoxy resin, 450-550 epoxide eq.	--	---	286.6	28.52
Methyl isobutyl ketone	201.1	30.10	89.4	13.38
Butyl cellosolve	--	--	60.3	8.04
Butyl alcohol	--	--	36.0	5.34
Toluene	104.7	14.53	--	--
Xylene	--	--	193.3	26.77
	1031.4	100.00	1213.0	100.00
Component B, Catalyst				
Polyamide resin solution, 70% N.V.	218.6	27.63	--	--
Amino silane	--	--	26.5	3.12
Butyl alcohol	139.9	20.73	6.3	0.94
Isopropyl alcohol	139.9	21.36	--	--
Toluene	218.6	30.28	--	--
Xylene	--	--	60.9	8.44
	717.0	100.00	93.7	12.50
Pigment volume concentration	22.5%		35.2%	

Epoxy-Polyamide, Amino Silane Experimental Primers

Ingredient	Zinc Chromate Formula 5 Pounds	Zinc Chromate Formula 5 Gallons	Strontium Chromate Formula 6 Pounds	Strontium Chromate Formula 6 Gallons
Component A, Pigmented Epoxy Resin				
Zinc chromate	177.6	6.18	--	--
Strontium chromate	--	--	208.1	6.18
Fibrous magnesium silicate	29.2	1.23	29.2	1.23
Suspension agent	2.1	0.14	2.1	0.14
Epoxy resin, 450-550 epoxide eq.	197.4	19.64	197.4	19.64
Urea formaldehyde resin	16.7	1.96	16.7	1.96
Methyl isobutyl ketone	62.7	9.38	62.7	9.38
Butyl cellosolve	42.1	5.62	42.1	5.62
Butanol	25.3	3.75	25.3	3.75
Xylene	135.5	18.77	135.5	18.77
	688.6	66.67	719.1	66.67
Component B, Catalyst				
Polyamide resin	106.3	12.88	106.3	12.88
Methyl isobutyl ketone	33.0	4.94	33.0	4.94
Butyl cellosolve	22.2	2.96	22.2	2.96
Butanol	13.3	1.97	13.3	1.97
Xylene	71.3	9.88	71.3	9.88
Amino silane	6.0	0.70	6.0	0.70
	252.1	33.33	252.1	33.33

Pigment volume concentration 18.1% (Formula 5); 18.1% (Formula 6)

Vinyl Zinc Chromate Primers

Ingredient	MIL-P-15930B Formula 7		Formula 8	
	Pounds	Gallons	Pounds	Gallons
Basic zinc chromate	78.1	2.49	130.5	4.16
Fibrous magnesium silicate	48.9	2.06	10.9	0.46
Lampbalck	1.9	0.13	2.1	0.14
Aluminum stearate	1.0	0.12	1.1	0.13
Vinyl chloride-acetate copolymer	141.4	12.48	144.0	12.71
Tricresyl phosphate	12.2	1.26	12.4	1.28
Methyl isobutyl ketone	336.5	50.38	335.2	50.18
Toluene	224.4	31.08	223.4	30.94
	844.4	100.00	859.6	100.00

Pigment volume concentration	25.9%	25.9%

Epoxy Primers, MIL-P-23377A (Amended) and Amino Silane Type

Ingredient	MIL-P-23377A Formula 9 Pounds	MIL-P-23377A Formula 9 Gallons	Amino Silane Formula 10 Pounds	Amino Silane Formula 10 Gallons
Component A, Pigmented Epoxy Resin				
Strontium chromate	212.1	6.85	186.4	6.02
Rutile titanium dioxide	40.6	1.16	35.7	1.02
Micronized magnesium silicate	86.9	3.85	76.3	3.38
Diatomaceous silica	45.5	2.73	39.8	2.39
Suspension agent	12.0	0.80	10.7	0.71
Silicone resin, 60% N.V.	--	---	5.5	0.67
Epoxy resin solution, 75% N.V., 450-550 epoxide eq.	321.2	35.45	--	--
Epoxy resin, 450-550 epoxide eq.	--	---	321.2	31.96
Methyl isobutyl ketone	222.3	33.28	89.9	13.46
Butyl cellosolve	--	--	60.5	8.07
Butyl alcohol	--	--	36.1	5.35
Xylene	--	--	194.7	26.97
Toluene	114.7	15.88	--	--
	1055.3	100.00	1056.8	100.00
Component B, Catalyst				
Polyamide resin solution, 70% N.V.	191.0	24.14	--	--
Amino silane	--	--	29.7	3.49
Butyl alcohol	146.2	21.66	6.1	0.90
Isopropyl alcohol	146.3	22.33	--	--
Toluene	230.1	31.87	--	--
Xylene	--	--	58.6	8.11
	713.6	100.00	94.4	12.50
Pigment volume concentration	27.5%		27.5%	

Epoxy Primers, Pigmentation and PVC of MIL-P-15930B

Ingredient	Polyamide Formula 11 Pounds	Polyamide Formula 11 Gallons	Amino Silane Formula 12 Pounds	Amino Silane Formula 12 Gallons
Component A, Pigmented Epoxy Resin				
Basic zinc chromate	245.9	7.84	208.6	6.65
Fibrous magnesium silicate	154.1	6.49	130.6	5.50
Lampblack	6.1	0.41	5.2	0.35
Aluminum stearate	3.2	0.38	2.7	0.32
Silicone resin, 60% N.V.	6.5	0.79	5.5	0.68
Epoxy resin, 450-550 epoxide eq.	259.6	25.83	329.5	32.79
Methyl isobutyl ketone	97.4	14.58	89.7	13.43
Butyl cellosolve	65.5	8.73	60.5	8.06
Butyl alcohol	39.2	5.81	36.1	5.35
Xylene	210.4	29.14	194.0	26.87
	1087.9	100.00	1062.4	100.00
Component B, Catalyst				
Polyamide resin	139.9	16.96	--	--
Amino silane	--	--	29.7	3.49
Methyl isobutyl ketone	138.7	20.76	--	--
Butyl cellosolve	93.5	12.46	--	--
Butyl alcohol	56.0	8.30	6.1	0.91
Xylene	299.8	41.52	58.5	8.10
	727.9	100.00	94.3	12.50
Pigment volume concentration	25.9%		25.9%	

Epoxy Primers, PVC of MIL-P-15930B, 90% Basic Zinc Chromate

Ingredient	Polyamide Formula 13 Pounds	Polyamide Formula 13 Gallons	Amino Silane Formula 14 Pounds	Amino Silane Formula 14 Gallons
Component A, Pigmented Epoxy Resin				
Basic zinc chromate	401.8	12.81	341.9	10.90
Fibrous magnesium silicate	34.0	1.43	28.7	1.21
Lampblack	6.4	0.43	5.5	0.37
Aluminum stearate	3.3	0.40	2.8	0.34
Silicone resin, 60% N.V.	6.5	0.80	5.5	0.68
Epoxy resin, 450-550 epoxide eq.	258.9	25.76	329.5	32.79
Methyl isobutyl ketone	97.5	14.60	89.7	13.43
Butyl cellosolve	65.7	8.76	60.5	8.06
Butyl alcohol	39.3	5.82	36.2	5.37
Xylene	210.8	29.19	193.9	26.85
	1124.2	100.00	1094.2	100.00
Component B, Catalyst				
Polyamide resin	139.5	16.91	--	--
Amino silane	--	--	29.7	3.49
Methyl isobutyl ketone	138.7	20.76	--	--
Butyl cellosolve	93.5	12.47	--	--
Butyl alcohol	56.1	8.31	6.1	0.91
Xylene	300.0	41.55	58.5	8.10
	727.8	100.00	94.3	12.50
Pigment volume concentration	25.9%		25.9%	

Epoxy Primers, PVC 35.2%, Pigmentation of MIL-P-15930B

Ingredient	Polyamide Formula 15 Pounds	Polyamide Formula 15 Gallons	Amino Silane Formula 16 Pounds	Amino Silane Formula 16 Gallons
Component A, Pigmented Epoxy Resin				
Basic zinc chromate	315.2	10.05	278.5	8.88
Fibrous magnesium silicate	197.5	8.32	174.5	7.35
Lampblack	7.9	0.53	6.9	0.49
Aluminum stearate	4.0	0.48	3.5	0.42
Silicone resin, 60% N.V.	5.4	0.66	4.9	0.60
Epoxy resin, 450-550 epoxide eq.	214.3	21.32	282.5	28.11
Methyl isobutyl ketone	98.0	14.67	90.6	13.56
Butyl cellosolve	66.0	8.80	61.0	8.13
Butyl alcohol	39.4	5.84	36.5	5.40
Xylene	211.8	29.33	195.6	27.09
	1159.5	100.00	1134.5	100.00
Component B, Catalyst				
Polyamide resin	115.5	14.00	--	--
Amino silane	--	--	26.2	3.08
Methyl isobutyl ketone	143.6	21.50	--	--
Butyl cellosolve	96.8	12.90	--	--
Butyl alcohol	58.1	8.60	6.4	0.95
Xylene	310.5	43.00	61.2	8.47
	724.5	100.00	93.8	12.50
Pigment volume concentration	35.2%		35.2%	

Epoxy Primers, PVC 35.2%, 90% of Pigment Basic Zinc Chromate

Ingredient	Polyamide Formula 17 Pounds	Polyamide Formula 17 Gallons	Amino Silane Formula 18 Pounds	Amino Silane Formula 18 Gallons
Component A, Pigmented Epoxy Resin				
Basic zinc chromate	511.0	16.29	431.9	13.77
Fibrous magnesium silicate	43.0	1.81	36.1	1.52
Lampblack	8.2	0.55	6.9	0.46
Aluminum stearate	4.3	0.51	3.7	0.44
Silicone resin, 60% N.V.	5.3	0.65	4.6	0.57
Epoxy resin, 450-550 epoxide eq.	211.8	21.07	267.1	26.58
Methyl isobutyl ketone	98.8	14.79	94.7	14.18
Butyl cellosolve	66.5	8.87	63.8	8.50
Butyl alcohol	39.8	5.89	38.1	5.65
Xylene	213.5	29.57	204.5	28.33
	1202.2	100.00	1151.4	100.00
Component B, Catalyst				
Polyamide resin	114.1	13.83	--	--
Amino silane	--	--	24.7	2.91
Methyl isobutyl ketone	143.9	21.54	--	--
Butyl cellosolve	97.0	12.93	--	--
Butyl alcohol	58.2	8.62	6.1	9.90
Xylene	311.0	43.08	62.7	8.69
	724.2	100.00	93.5	12.50
Pigment volume concentration	35.2%		35.2%	

Polyurethane Primer, Pigmentation and PVC of MIL-P-15930B

Ingredient	Formula 19 Pounds	Formula 19 Gallons
Component A, Pigmented Polyester		
Basic zinc chromate	262.9	8.38
Fibrous magnesium silicate	164.5	6.93
Lampblack	6.4	0.43
Aluminum stearate	3.3	0.40
Silicone resin, 60% N.V.	0.6	0.06
Polyester resin, 260-280 hydroxy number	245.5	22.46
Ethyl acetate (urethane grade)	228.2	30.39
Methyl ethyl ketone	73.2	10.93
Cellosolve acetate (urethane grade)	90.1	11.12
Xylene	63.5	8.79
Zinc octoate, 35% N.V.	0.8	0.11
	1139.0	100.00
Component B, Hexamethylene Diisocyanate Adduct		
Diisocyanate adduct, 75% N.V.	299.2	33.50
Cellosolve acetate (urethane grade)	60.6	7.48
Methyl ethyl ketone	60.4	9.02
	420.2	50.00
Pigment volume concentration	25.9%	

APPENDIX C - TEST DATA

TABLE I

Panama Exposure, Breakwater

Steel - Zinc Phosphate Pretreated, TT-C-490 Type I
Topcoat - TT-E-529, Class A, Olive Drab

		Exposure Time - Ratings (Appendix A, TABLE II)											
		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	3	3	5	5	0-1/4	0-1/4	5	5	0-1/2	0-1/2	5	5
	None	3	3	A-4	4	0-1/4	0-1/4	B-0	0-2	-	-	-	-
2	TT-E-529	2	3	5	3-8	0-1/4	0-5/16	5	2-8	0-3/8	0-3/8	5	2-8
	None	0-3/8	3	A-1	3-8	-	-	-	-	-	-	-	-
3	TT-E-529	2	2	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
	None	2	2	A-2	3-8	0-1/2	0-1/2	B-3	3-8	-	-	-	-
4	TT-E-529	2	2	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
	None	2	2	5	5	0-3/8	0-3/8	B-2	3-8	-	-	-	-
5	TT-E-529	0-5/16	0-1/4	5	5	0-1/2	0-1/2	5	5	0-1	0-1	5	5
	None	0-5/16	0-5/16	A-4	4	0-1/2	0-1/2	A-2	4	-	-	-	-
6	TT-E-529	0-5/16	0-1/4	5	5	0-1/2	0-1/2	5	5	0-3/4	0-3/4	5	5
	None	0-5/16	0-1/2	A-3	3-8	-	-	-	-	-	-	-	-

TABLE 2

Panama Exposure, Breakwater

Aluminum - Solvent Cleaned
Topcoat - TT-E-529, Class A, Olive Drab

		Exposure Time - Ratings (Appendix A, TABLE II)											
		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	0-1	0-1	5	5	0-1	0-1	B-3	3-6	-	-	-	-
	None	0-1	0-1	B-0	0-6	-	-	-	-	-	-	-	-
2	TT-E-529	5	5	5	5	5	4	5	5	5	4	5	5
	None	5	5	C-1	4	-	-	-	-	-	-	-	-
3	TT-E-529	3	0-1/2	5	5	0-1	0-1	5	5	-	-	-	-
	None	5	5	5	5	3	5	5	5	1	5	5	5
4	TT-E-529	3	5	5	5	3	5	5	5	3	5	5	5
	None	5	5	5	5	5	5	5	5	4	5	5	5
5	TT-E-529	5	5	5	5	4	5	5	5	3	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	5	5
6	TT-E-529	5	5	5	5	5	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	B-3	3-8	5	5	B-3	3-8

TABLE 3

Panama Exposure, Breakwater

Aluminum - Chemically Pretreated, MIL-C-5541, Type II
Topcoat - TT-E-529, Class A, Olive Drab

		Exposure Time - Ratings (Appendix A, TABLE II)											
		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	4	4	5	5	4	4	5	5	4	4	5	5
	None	4	4	5	5	3	4	5	5	2	4	5	5
2	TT-E-529	5	5	5	5	5	5	5	5	4	4	5	5
	None	5	5	C-0	4	-	-	-	-	-	-	-	-
3	TT-E-529	5	5	5	5	5	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	5	5	4	5	5	5
4	TT-E-529	5	5	5	5	5	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	5	5	5	5	5	5
5	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	5	5	5	5	5	5
6	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	5	5	4	5	5	5

TABLE 4

Panama Exposure, Breakwater

Magnesium - Solvent Cleaned
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	0-5/16	0-5/16	5	5	-	-	-	-	-	-	-	-
	None	0	0	0	1-6	-	-	-	-	-	-	-	-
2	TT-E-529	4	3	A-3	3-8	3	3	A-2	2-8	1	1	B-2	1-6
	None	0	0	0	0	-	-	-	-	-	-	-	-
3	TT-E-529	5	5	5	5	3	1	5	5	1	1	A-4	4-6
	None	3	2	B-4	2-8	0-1/2	0-1/2	A-2	2-6	-	-	-	-
4	TT-E-529	5	5	5	5	4	5	5	5	4	5	C-4	5
	None	4	4	A-2	3-8	3	4	A-2	1-6	-	-	-	-
5	TT-E-529	3	3	5	5	0-1/2	1	5	5	0-1/2	0-1/4	5	5
	None	4	5	5	5	4	5	A-3	5	3	4	A-3	4-8
6	TT-E-529	3	2	B-2	2-6	-	-	-	-	-	-	-	-
	None	0	0	B-2	2-6	-	-	-	-	-	-	-	-

TABLE 5

Panama Exposure, Breakwater

Magnesium - Chemically Pretreated, MIL-M-3171 Type I
Topcoat - TT-E-529, Class A, Olive Drab

		Exposure Time - Ratings (Appendix A, TABLE II)											
		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	4	4	5	5	3	4	5	5	3	3	5	5
	None	3	3	A-1	1-6	-	-	-	-	-	-	-	-
2	TT-E-529	5	5	5	5	4	5	5	5	4	4	5	5
	None	4	5	A-3	4-8	4	5	A-3	2-6	-	-	-	-
3	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	A-4	4-8	4	5	A-4	4-8
4	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	5	4	5	5	A-4	4-8
5	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	A-4	4-8
6	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	A-3	3-8	4	5	A-3	3-8

TABLE 6

Panama Exposure, Breakwater

Magnesium - Chemically Pretreated, MIL-M-3171 Type III
Topcoat - TT-E-529, Class A, Olive Drab

		Exposure Time - Ratings (Appendix A, TABLE II)											
		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Undercut	Surface	Substrate	Score	Undercut	Surface	Substrate	Score	Undercut	Surface	Substrate
1	TT-E-529	4	4	5	5	4	4	5	5	3	3	5	5
	None	4	4	5	5	4	4	5	5	3	3	B-4	4-6
2	TT-E-529	5	5	5	5	4	5	5	5	4	5	A-3	3-8
	None	5	5	A-4	4-8	3	5	A-3	3-8	3	5	A-3	3-8
3	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	5	5
4	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	5	5	5	5	5	5	5	5
5	TT-E-529	5	5	5	5	5	5	5	5	5	5	5	5
	None	5	5	5	5	5	5	5	5	5	5	5	5
6	TT-E-529	5	5	5	5	5	5	5	5	5	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	5	5

TABLE 7

Panama Exposure, Breakwater

Magnesium - Anodically Pretreated, MIL-M-45202 Type I
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

		6 Months				15 Months				21 Months			
Primer	Topcoat	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	TT-E-529	3	5	5	5	3	5	5	5	3	3	5	5
	None	2	2	A-1	1	-	-	-	-	-	-	-	-
2	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	A-1	5	-	-	-	-	-	-	-	-
3	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	3	5	5	5	3	3	5	5
4	TT-E-529	5	5	5	5	4	5	5	5	4	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	5	5
5	TT-E-529	5	5	5	5	5	5	5	5	5	5	5	5
	None	5	5	5	5	4	5	5	5	4	5	5	5
6	TT-E-529	5	5	5	5	5	5	5	5	5	5	5	5
	None	5	5	5	5	4	5	A-3	3-8	4	5	A-1	1-8

TABLE 8

Panama Exposure, Breakwater

Steel - Zinc Phosphate Pretreated, TT-C-490 Type I
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	3	3	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
4	2	2	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
7	2	2	5	5	0-3/8	0-3/8	5	5	0-5/8	0-5/8	5	5
8	3	3	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	B-4	4
9	2	2	5	5	0-3/8	0-3/8	5	5	0-9/16	0-9/16	5	5
10	2	2	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
11	1	1	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
12	2	2	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
13	1	1	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
14	3	3	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	B-3	3
15	1	1	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
16	2	2	5	5	0-5/16	0-5/16	5	5	0-1/2	0-1/2	B-4	4
17	1	1	5	5	0-3/8	0-3/8	5	5	0-1/2	0-1/2	5	5
18	2	2	B-3	3	0-1/2	0-1/2	B-3	3	0-5/8	0-5/8	B-3	3
19	3	3	5	5	0-5/16	0-5/16	5	5	0-1/2	0-1/2	B-4	4

TABLE 9

Panama Exposure, Breakwater

Aluminum - Alkali Cleaned
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	2	2	5	5	0-1	0-1	5	5	-	-	-	-
4	4	4	5	5	4	4	5	5	3	3	5	5
7	4	4	5	5	0-1/2	0-1/2	5	5	0-5/8	0-5/8	5	5
8	5	5	5	5	4	4	5	5	3	3	5	5
9	5	5	5	5	4	4	5	5	3	3	5	5
10	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	0-1/2	0-1/2	5	5	0-5/8	0-5/8	5	5
12	4	5	5	5	0-1/4	0-1/4	5	5	0-1/4	0-1/4	5	5
13	5	5	5	5	4	4	5	5	4	4	5	5
14	5	5	5	5	4	4	5	5	4	4	5	5
15	5	5	5	5	4	4	5	5	4	4	5	5
16	5	5	5	5	4	4	5	5	4	4	5	5
17	5	5	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5	5	5
19	3	5	5	5	0-3/	0-3/4	5	5	-	-	-	-

TABLE 10

Panama Exposure, Breakwater

Aluminum - Chemically Pretreated, MIL-C-5541, Type II
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

Primer	6 Months				15 Months				21 Months			
	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	4	4	5	5	0-1/4	0-1/4	5	5	0-1/4	0-1/4	5	5
4	5	5	5	5	4	4	5	5	4	4	5	5
7	5	5	5	5	5	4	5	5	4	4	5	5
8	5	5	5	5	4	4	5	5	4	4	5	5
9	5	5	5	5	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5	4	4	5	5
11	5	5	5	5	5	5	5	5	5	5	5	5
12	5	5	5	5	4	4	5	5	4	4	5	5
13	5	5	5	5	5	5	5	5	5	5	5	5
14	5	5	5	5	4	4	5	5	4	4	5	5
15	5	5	5	5	4	4	5	5	4	4	5	5
16	5	5	5	5	4	4	5	5	4	4	5	5
17	5	5	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5	5	5
19	5	5	5	5	4	4	5	5	3	3	5	5

TABLE 11

Panama Exposure, Breakwater

Magnesium - Alkali Cleaned
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	3	3	5	5	0-3/8	0-3/8	B-3	3	-	-	-	-
4	5	5	5	5	5	5	5	5	4	5	5	5
7	4	4	A-3	4	2	2	B-3	3	0-1/4	0-1/4	B-3	3
8	4	5	A-3	4	2	2	B-4	4	0-1/4	0-1/4	B-0	2
9	4	5	A-3	4	3	3	B-3	4	1	1	B-2	3
10	5	5	A-3	4	4	4	B-2	3	4	4	B-2	3
11	4	4	5	5	0-1/2	0-1/2	C-4	4	0-1/2	0-1/2	B-4	4
12	5	5	5	5	4	4	5	5	4	4	5	5
13	2	5	A-4	5	0-1/2	0-1/2	A-4	5	0-1/2	0-1/2	B-3	4
14	4	5	A-4	5	4	5	A-4	5	4	5	A-4	5
15	5	5	5	5	4	4	5	5	3	3	5	5
16	5	5	5	5	4	4	5	5	4	4	5	5
17	4	4	5	5	3	3	B-3	4	0-1/2	0-1/2	B-3	4
18	5	5	5	5	4	4	A-3	4	4	4	B-3	4
19	3	5	C-3	4	0-1/4	0-1/4	B-0	2	-	-	-	-

TABLE 12

Panama Exposure, Breakwater

Magnesium - Anodically Pretreated, MIL-M-45202, Type I
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	5	5	5	5	4	4	5	5	4	4	5	5
4	5	5	5	5	4	4	5	5	4	4	5	5
7	5	5	5	5	4	4	5	5	4	4	5	5
8	5	5	5	5	4	4	5	5	4	4	5	5
9	5	5	5	5	4	4	5	5	4	4	5	5
10	5	5	5	5	4	4	5	5	4	4	5	5
11	5	5	5	5	4	4	5	5	4	4	5	5
12	5	5	5	5	4	4	5	5	4	4	5	5
13	5	5	5	5	4	4	5	5	4	4	5	5
14	5	5	5	5	4	4	5	5	4	4	B-4	4-8
15	5	5	5	5	4	4	5	5	4	4	5	5
16	5	5	5	5	4	4	5	5	4	4	5	5
17	5	5	5	5	4	4	5	5	4	4	5	5
18	5	5	5	5	4	4	5	5	4	4	B-4	4-8
19	5	5	5	5	4	4	5	5	4	4	5	5

TABLE 13

Panama Exposure, Rain Forest

Steel - Zinc Phosphate Pretreated, TT-C-490 Type I
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	5	5	5	5	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5	5	5	5
7	5	5	5	5	4	4	5	5	4	4	5	5
8	5	5	5	5	5	5	5	5	4	4	5	5
9	5	5	5	5	5	5	5	5	4	4	5	5
10	5	5	5	5	5	5	5	5	4	4	5	5
11	5	5	5	5	5	5	5	5	4	4	5	5
12	5	5	5	5	5	5	5	5	4	4	5	5
13	5	5	5	5	5	5	5	5	4	4	5	5
14	5	5	5	5	5	5	5	5	4	4	5	5
15	5	5	5	5	5	5	5	5	4	4	5	5
16	5	5	5	5	5	5	5	5	4	4	5	5
17	5	5	5	5	5	5	5	5	4	4	5	5
18	5	5	5	5	5	5	5	5	4	4	5	5
19	5	5	5	5	5	5	5	5	4	4	5	5

TABLE 14

Panama Exposure, Rain Forest

Aluminum - Alkali Cleaned
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	5	5	5	5	0-1/2	0-1/2	5	5	0-1/2	0-1/2	5	5
4	5	5	5	5	4	5	5	5	4	5	5	5
7	5	5	5	5	5	5	5	5	5	5	5	5
8	5	5	5	5	5	5	5	5	5	5	5	5
9	5	5	5	5	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	4	4	5	5	3	3	5	5
12	5	5	5	5	5	5	5	5	5	5	5	5
13	5	5	5	5	5	5	5	5	5	5	5	5
14	5	5	5	5	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5	5	5
19	5	5	5	5	0-1/4	0-1/4	5	5	0-5/8	0-5/8	5	5

TABLE 15

Panama Exposure, Rain Forest

Aluminum - Chemically Pretreated, MIL-C-5541, Type II
Topcoat - TT-E-529, Class A, Olive Drab

	Exposure Time - Ratings (Appendix A, TABLE II)											
	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	4	4	5	5	4	4	5	5	3	3	5	5
4	5	5	5	5	5	5	5	5	4	4	5	5
7	5	5	5	5	5	5	5	5	4	4	5	5
8	5	5	5	5	5	5	5	5	5	5	5	5
9	5	5	5	5	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	5	5	5	4	4	5	5
12	5	5	5	5	5	5	5	5	4	4	5	5
13	5	5	5	5	5	5	5	5	5	5	5	5
14	5	5	5	5	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5	5	5
19	5	5	5	5	4	5	5	5	3	5	5	5

TABLE 16

Panama Exposure, Rain Forest

Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE 11)

Primer	6 Months				15 Months				21 Months			
	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	5	5	5	5	5	5	C-3-1/64	4-1/64	5	5	C-0-1/64	3-1/64
4	5	5	5	5	5	5	5	5	5	5	5	5
7	5	5	5	5	5	5	5	5	5	5	5	5
8	5	5	5	5	5	5	5	5	5	5	C-0-1/32	C-0-1/32
9	5	5	C-0-1/32	5	-	-	-	-	-	-	-	-
10	5	5	C-0-1/32	5	5	5	C-2-1/32	5	5	5	C-0-1/32	5
11	5	5	5	5	5	5	5	5	5	5	C-0-1/32	3-1/32
12	5	5	5	5	5	5	5	5	5	5	5	5
13	5	5	5	5	5	5	5	5	5	5	5	5
14	5	5	5	5	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5	5	5	C-2-8	4
16	5	5	5	5	5	5	5	5	5	5	C-2-8	4
17	0-1/4	0	5	5	0-1/4	0	5	5	0-1/2	0-1/2	5	5
18	5	5	5	5	5	5	5	5	5	5	C-4-8	4
19	5	5	C-0-8	3	-	-	-	-	-	-	-	-

TABLE 17

Panama Exposure, Rain Forest

Magnesium - Anodically Pretreated, MIL-M-45202 Type I
Topcoat - TT-E-529, Class A, Olive Drab

Exposure Time - Ratings (Appendix A, TABLE II)

	6 Months				15 Months				21 Months			
Primer	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate	Score	Under-cut	Surface	Sub-strate
1	5	5	5	5	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5	5	5	5
7	5	5	5	5	5	5	5	5	5	5	5	5
8	5	5	5	5	5	5	5	5	5	5	C-0-1/32	4
9	5	5	5	5	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	5	5	5	5	5	5	5
12	5	5	5	5	5	5	5	5	5	5	5	5
13	5	5	5	5	5	5	5	5	5	5	C-4-1/64	5
14	5	5	5	5	5	5	5	5	5	5	C-4-1/64	5
15	5	5	5	5	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5	5	5
19	5	5	5	5	5	5	5	5	5	5	C-3-8	4

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Some currently employed specification epoxy primers and experimental formulations were exposed at the Panama test sites for corrosion resistance studies. Inhibiting pigments considered included strontium, zinc and basic zinc chromates up to 90% by weight of the total pigmentation at different pigment volume concentrations. Polyamide and amino-silane curing agents were used. Experimental vinyl and polyurethane primers offered no significant improvement in corrosion resistance when compared to two existing specification primers, particularly on pretreated substrates. It is recommended that MIL-P-52192, Primer Coat, Epoxy be used for ferrous substrates and MIL-P-23377, Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant, for aluminum, magnesium or bi-metallic materials.

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